

## *Phlegmariurus changii* (Huperziaceae), a New Hanging Firmoss from Taiwan

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ABSTRACT.—We describe and illustrate a new firmoss, *Phlegmariurus changii* (Huperziaceae), which is endemic to eastern Taiwan. This new species is most similar to *Phlegmariurus carinatus* (Desv. ex Poiret) Ching; however, it differs by leaves that are flat abaxially. In addition, the sporophylls and trophophylls are conspicuously dimorphic for *Phlegmariurus changii*, but essentially monomorphic in *Phlegmariurus carinatus*. The ecology, conservation status, and morphology of *P. changii* is compared to that of species in three other sections (Sect. *Phlegmariurus*, L. B. Zhang, Sect. *Huperzioides* H. S. Kung et L. B. Zhang, and Sect. *Carinaturus* (Herter) H. S. Kung et L. B. Zhang) of *Phlegmariurus* in East Asia.

KEY WORDS.—*Phlegmariurus*, flora of Taiwan, taxonomy, ornamental fern, tassel fern, extinct in the wild

In the spring of 2006, we collected a unique hanging firmoss at Hsilin Village, Wanrong Township, Hualien County in eastern Taiwan. After consulting the relevant literature (Ching, 1981b; Ching, 1981a; Ching and Zhang, 1983; Ching, 1982; Holub, 1991; Kuo, 1985; Li *et al.*, 1975; Ma, 1990; Medeiros *et al.*, 1996; Wagner *et al.*, 1999; Wagner *et al.*, 1995; Wagner, 1993; Yang, 1984; Zhang, 2004; Zhang and Kung, 1999; Zhang and Kung, 2000; Fernández Prieto *et al.*, 2008; Rothmaler, 1944; Knapp, 2011; Kuo, 1997; Huang, 1994) and abundant herbarium specimens, we found that this species is new and we describe it herein.

This species belongs to the Lycopodiales. The Lycopodiales were historically considered a single family, the Lycopodiaceae, which contained two genera, *Phylloglossum* Kunze and *Lycopodium* L. *Phylloglossum* is a genus containing only one species and endemic to Australia and New Zealand, whereas *Lycopodium sensu* Linnaeus are widely distributed in temperate and tropical regions. *Lycopodium* L. is a complex group and has undergone many changes in taxonomy and nomenclature (Holub, 1991; Wagner and Beitel,

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1992; Wagner, 1993; Øllgaard, 1987). *Lycopodium* has been separated into two families, the Urostachyaceae Rothm. (=Huperziaceae Rothm.) and the Lycopodiaceae (Rothmaler, 1944), and several genera. There are two genera—*Phlegmariurus* and *Huperzia* Bernh.—in Huperziaceae. In this article, we follow Wagner's classification and include this species in *Phlegmariurus* (Wagner and Beitel, 1992).

Many species of *Phlegmariurus* (Herter) Holub are important traditional medicines and popular ornamental ferns in the flower markets, such as *Phlegmariurus squarrosus* (Forst.) L'ève et L'ève, *P. carinatus* (Desv. ex Poiret) Ching, and *P. cunninghamioides* (Hayata) Ching. Consequently, over-collection of plants from the wild for medicinal and horticultural purposes threatens many species (Yumkham and Singh, 2011). Of the ten species of *Phlegmariurus* that occur in Taiwan, all but *P. fordii* (Baker) Ching are threatened (Moore, 2000; Moore, 2001; Kuo, 1997). This makes the finding of a new species in Taiwan important.

***Phlegmariurus changii*** T. Y. Hsieh, *sp. nov.* TYPE.—TAIWAN. Hualien County: Wanrong Township, Hsilin Village. 6 April 2006, *Tung-Yu Hsieh 516* (holotype: TAI 281321). **Figs. 1, 2.**

This new species is similar to *P. carinatus* (Desv. ex Poiret) Ching, but differs by having leaves that are flat, vs. carinate or raised abaxially in *P. carinatus*.

Epiphytes, pendant firmoss; stems 0.6–0.9 m long, 3–5 mm in diameter, dichotomously branching 5–8 times. Leaves sessile, leathery, lanceolate, entire, with tapering apex, 7–9 mm long, 3–4 mm wide, imbricate, pointing towards the apex of the shoot, appressed, decreasing in size towards apex and gradually changing into sporophylls. Fertile spikes terminal, 0.15–0.2 m long, 2 mm thick. Sporangia reniform, borne in the axil of the sporophyll, green turning to yellow when mature, ca. 1.3 × 1.2 mm. Spores trilete, radially symmetrical, foveolate, tetrahedral from the polar view, having a laesura with three radiating branches near to the equator, ca. 34 × 32 μm.

ADDITIONAL SPECIMENS EXAMINED.—TAIWAN. Hualien County: Wanrong Township, Hsilin Village, ca. 200 m alt., 6 Apr 2006, *T. C. Hsu 461* (TAIF); same loc., *s.d.*, *Liang-Ru Chang s.n.* (TAI).

ETYMOLOGY.—The specific epithetic commemorates the original discoverer of this species, Liang-Ru Chang. He is an active amateur fern and orchid lover (Lin *et al.*, 2006).

NOTES.—Liang-Ru Chang first found this hanging firmoss in the spring of 2006, from the type locality at Hsilin Village, Wanrong Township, Hualien County. The holotype was collected from the trunk of an old *Schefflera* tree (*Schefflera octophylla* (Lour.) Harms) on a cliff beside a valley, at about 200m altitude, growing with many plants of *Vittaria zosterifolia* Willd. (Fig. 2A).

After the initial discovery, the first author conducted a long-term, regular and exhaustive field investigation for *P. changii* thorough the island during the field work for his PhD study in 2006–2011 (Hsieh *et al.*, 2007; Hsieh *et al.*,

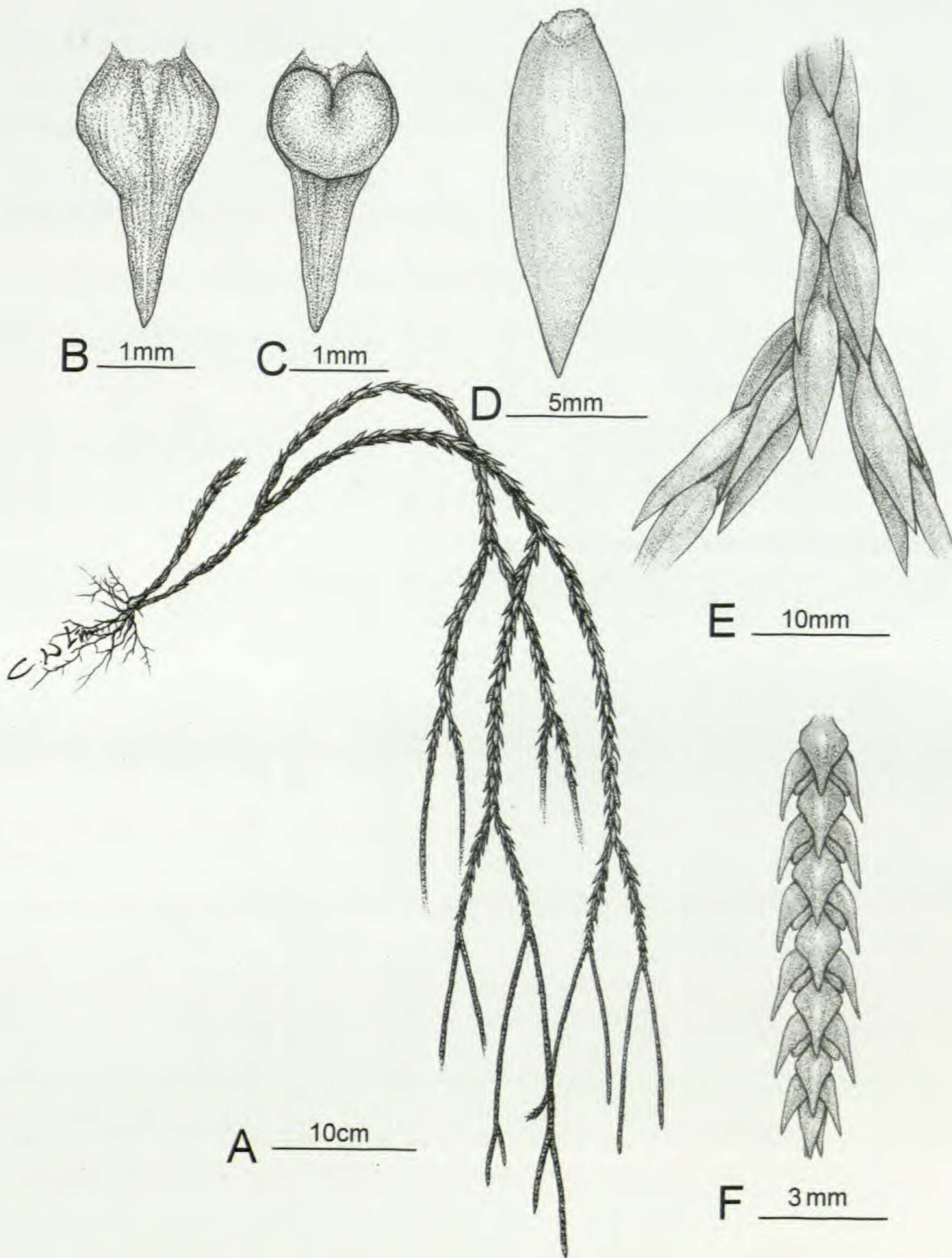


FIG. 1. *Phlegmariurus changii* T. Y. Hsieh. A. Whole plant; B. Abaxial side of sporophyll; C. Adaxial side of sporophyll and sporangium; D. Trophophyll; E. Middle part of stem; F. Fertile spike.

2011; Hsieh, 2011). During this period, only three habitats were found. All three were found at separate locations in lowland of Taitung and Hualien County, in eastern Taiwan. Unfortunately, all known wild individuals have since been removed by other collectors. There are two cultivated individuals

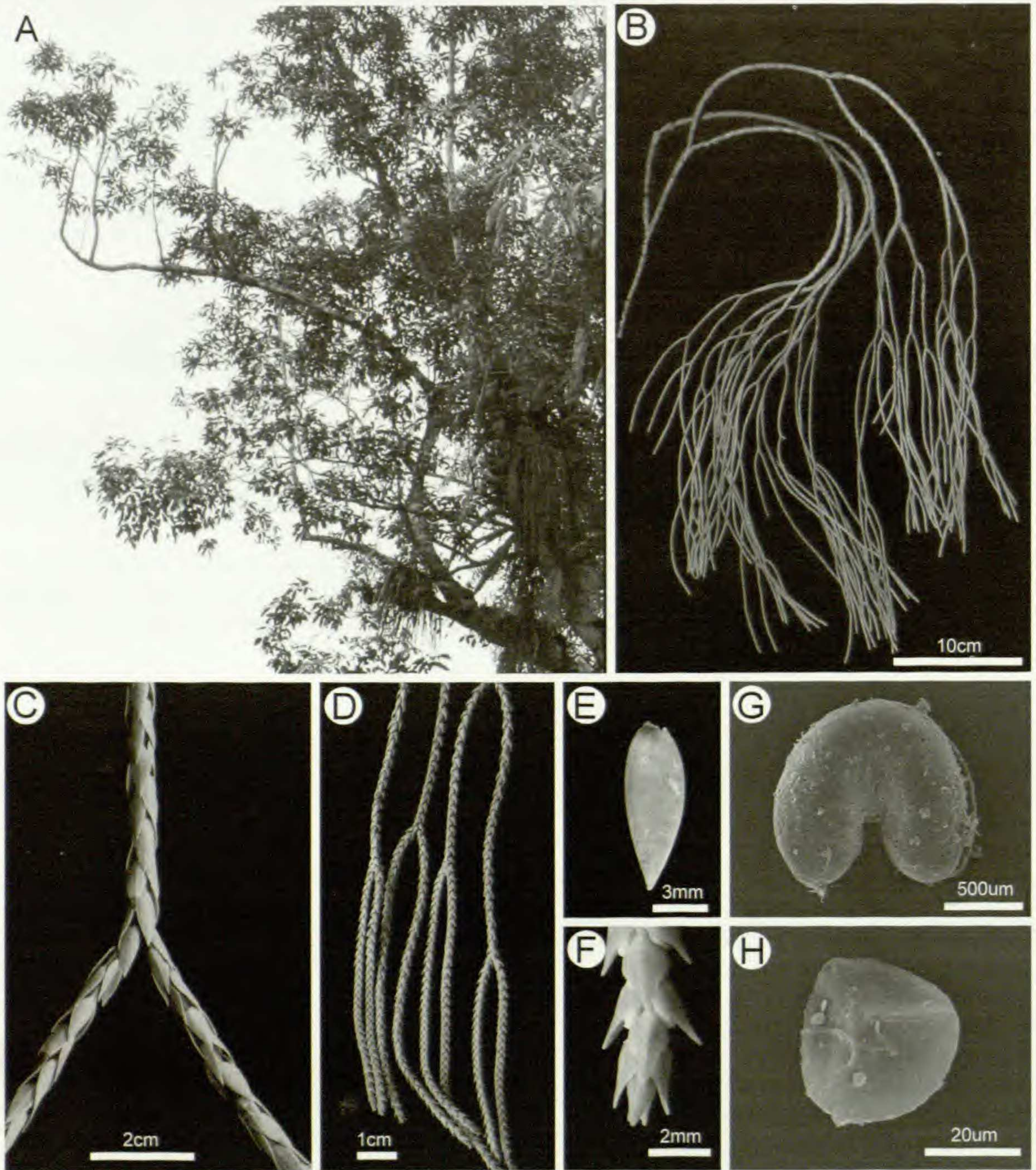


FIG. 2. *Phlegmariurus changii* T. Y. Hsieh. A. Habitat; B. Whole plant; C. Middle part of stem; D. Fertile spikes; E. Trophophyll; F. Sporophylls; G. Sporangium, SEM microphotograph; H. Spore, SEM microphotograph.

as far as we know. Given this situation, according to the IUCN (The International Union for Conservation and Natural Resources) ranking system (IUCN, 2008), this species should be considered extinct in the wild (EW) temporarily. We will continue our field investigation for this species and hope that we can find the individuals of this species in the wild again in the future. By doing so, we can re-evaluate the conservation status of this species.

*Phlegmariurus carinatus* is the only species that is morphologically similar to *P. changii*. *Phlegmariurus changii* can be distinguished from species in the

three sections of *Phlegmariurus* in East Asia., Sect. *Phlegmariurus*, L. B. Zhang, Sect. *Huperzioides* H. S. Kung et L. B. Zhang, and Sect. *Carinaturus* (Herter) H. S. Kung et L. B. Zhang. *Phlegmariurus changii* can be distinguished from species in both Sect. *Phlegmariurus* and Sect. *Huperzioides* by having all leaves appressed on the stem, imbricate, and pointing towards the apex of the shoot. This is not the case in the later two groups (Zhang and Kung, 1999; Zhang and Kung, 2000). Compared to species of Sect. *Carinaturus*, the leaves of *P. changii* are relatively large and flat. By comparison, the leaves of Sect. *Carinaturus* are carinate or raised on the abaxial side, whereas they are but flat in *P. changii*. Sporophylls and trophophylls are homomorphic for species of Sect. *Carinaturus* (Zhang and Kung, 2000), but dimorphic for *P. changii* (Figs. 1B, 1D, 2E, 2F).

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#### LITERATURE CITED

- CHING, R. C. 1981a. The taxonomy of Chinese Lycopodiaceae (sen. lat.) II. Acta Botan. Yunnan. 3:291–305.
- CHING, R. C. 1981b. The taxonomy of Chinese Lycopodiaceae (sen. lat.) I. Acta Botan. Yunnan. 3:1–9.
- CHING, R. C. 1982. The taxonomy of Chinese Lycopodiaceae (sen. lat.) III–IV. Acta Botan. Yunnan. 4:119–128.
- CHING, R. C. and C. F. ZHANG. 1983. New ferns of Zhejiang Province. Bull. Bot. Res., Harbin 3:1–55.
- FERNÁNDEZ PRIETO, J. A., C. AGUIAR, E. DIAS, M. D. L. A. F. CASADO and J. HOMET. 2008. The genus *Huperzia* (Lycopodiaceae) in the Azores and Madeira. Bot. J. Linn. Soc. 158:522–533.
- HOLUB, J. 1991. Some taxonomic changes within Lycopodiales. Folia Geobot. Phytotax. 26:81–94.
- HSIEH, T. Y. 2011. Taxonomy and distribution of indigenous *Actinidia* in Taiwan. PhD, National Chung-Hsing University, Taichung, Taiwan.
- HSIEH, T. Y., T. C. HSU, Y. KONO, S. M. KU and C. I. PENG. 2007. *Gentiana bambuseti* (Gentianaceae), a new species from Taiwan. Botanical Studies 48:349–355.
- HSIEH, T. Y., S. M. KU, C. T. CHIEN and Y. T. LIOU. 2011. Classifier modeling and numerical taxonomy of *Actinidia* (Actinidiaceae) in Taiwan. Botanical Studies 52:337–357.
- HUANG, T. C. E. A. (ed.) 1994. Flora of Taiwan, 2nd edition., Vol. 1., Taipei, Editorial Committee of the Flora of Taiwan.
- IUCN. 2008. IUCN Red list categories and criteria: version 7, IUCN—The World Conservation Union, Gland, Switzerland and Cambridge, United Kingdom.
- KNAPP, R. 2011. Ferns and Fern Allies of Taiwan, KBCC Press.
- KUO, C. M. 1985. Taxonomy and phytogeography of Taiwanese pteridophytes. Taiwaniana 30:5–100.
- KUO, C. M. 1997. *Lycopodium*. Rare and Endangered Plants in Taiwan (II), Council of Agriculture, Taipei.
- LI, H. L., T. S. LIU, T. P. HUANG, T. KOYAMA and E. CHARLES. 1975. Flora of Taiwan (1st edn.), Vol. 1, Pteridophyta and Gymnospermae, Epoch Publishing Company.

- LIN, W. M., L. L. KUO HUANG and T. LIN. 2006. Newly discovered native orchids of Taiwan. *Taiwania* 51:162.
- MA, C. Y. 1990. New Taxa of genus *Phlegmariurus* from China. *Bull. Bot. Res.*, Harbin 10:57–169.
- MEDEIROS, A., W. WAGNER JR and R. HOBODY. 1996. A new Hawaiian hanging firmoss (Lycopodiaceae: *Phlegmariurus*) from the eastern Hawaiian Islands. *Amer. Fern J.* 86:89–97.
- MOORE, S. J. 2000. *Lycopodium*. Rare and Endangered Plants in Taiwan (V), Council of Agriculture, Taipei.
- MOORE, S. J. 2001. *Lycopodium*. Rare and Endangered Plants in Taiwan (VI), Council of Agriculture, Taipei.
- ØLLGAARD, B. 1987. A revised classification of Lycopodiaceae s. *lat.* *Opera Bot.* 92:153–178.
- ROTHMALER, W. 1944. Pteridophyten-Studien I. Repertorium novarum specierum regni vegetabilis 54:55–82.
- WAGNER, W., F. S. WAGNER and T. FLYNN. 1995. Taxonomic notes on pteridophytes of Hawaii. *Contr. Univ. Michigan Herb.* 20:241–260.
- WAGNER, W. H. 1993. A New Combination for a North American Lycopod. *Novon* 3:305.
- WAGNER, W. H. and J. M. BEITEL. 1992. Generic classification of modern North American Lycopodiaceae. *Ann. Missouri Bot. Gard.* 79:676–686.
- WAGNER, W. H., D. D. PALMER and R. W. HOBODY. 1999. Taxonomic notes on the pteridophytes of Hawaii: II. *Contr. Univ. Michigan Herb.* 22:135–187.
- YANG, C. Y. 1984. A new species of the genus *Phlegmariurus* from Guangxi, China. *Acta Phytotax. Sin.* 22:87–88.
- YUMKHAM, S. D. and P. K. SINGH. 2011. *Huperzia squarrosa* (G. Forst.) Trev. (Lycopodiaceae) in Manipur: Taxonomy and Biological Aspects. *Taiwania* 56:157–164.
- ZHANG, L. B. 2004. *Phlegmariurus*. *Flora Reipublicae Popularis Sinicae* 6:31–54.
- ZHANG, L. B. and H. S. KUNG. 1999. On the taxonomy of *Phlegmariurus* (Herter) Holub sect. *Huperzioides* H. S. Kung et L. B. Zhang (sect. nov.) with notes on the infrageneric classification of the genus *Phlegmariurus* in China. *Acta Phytotax. Sin.* 37:40–53.
- ZHANG, L. B. and H. S. KUNG. 2000. Two sections of *Phlegmariurus* (Herter) Holub. (Huperziaceae) from China. *Acta Phytotax. Sin.* 38:23–29.